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AUTHOR Cobern, William W.; And Others
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ABSTRACT

To date, science educators have not studied what students believe about the world, beliefs rooted and nurtured in students' socio-cultural environments. American society is increasingly pluralistic and there are several cultural subgroups traditionally underrepresented in science. A new approach is for American science educators to consider the possibility that science is a second culture experience for many students. Cultural studies in science education can contribute significantly to an understanding of the barriers to effective science education. It is important for science educators to understand the fundamental, culturally based beliefs about the world that students bring to class, and how these beliefs are supported by students' cultures; because science education is successful only to the extent that science can find a niche in the cognitive and socio-cultural milieu of students. The purpose of the research was to gain an understanding of high school students' fundamental beliefs about the world, and how their personal/cultural environments foster and support those beliefs. The methodology used was ethnographic, involving the extensive interviewing of students. The research also involved active high school science teachers as teacher-researchers. Interview sequences, tasks, and scope items are included. (JRM)

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ED 388 501

World View Investigations and Science Education: A Synopsis of Methodology[1]

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A paper presentation at the 1995 Annual Meeting of the National Association for Research in Science Teaching, San Francisco

William W. Cobern, Ph.D.
Associate Professor of Science Education
College of Education
Arizona State University West
Phoenix Arizona
85069-7100

with

Ms Adrienne T. Gibson
Chair, Science Department
and
Mr Scott A. Underwood
Science Teacher
Cactus Shadows High School
Cave Creek, Arizona

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ABSTRACT

To date, science educators have not studied what students believe about the world, beliefs rooted and nurtured in students' socio-cultural environments. If one were speaking of a non-Western, developing nation, one would speak of students' traditional culture in contrast to the culture of science. Americans, on the other hand, assume that science is a natural part of American students' culture. However, there is widespread disinterest in science. Also, American society is increasingly pluralistic, and there are several cultural subgroups traditionally under represented in science. A new approach is for American science educators to consider the possibility that science is a second culture experience for many students. Traditionally, the study of culture is left to the cultural anthropologists. However, in recent years scholars in several disciplines have undertaken cultural studies in which they investigate the validity of cultural assumptions in their fields. Similarly, cultural studies in science education can contribute significantly to our understanding of the barriers to effective science education. We suggest that it is important for science educators to understand the fundamental, culturally based beliefs about the world that students bring to class, and how these beliefs are supported by students' cultures; because, science education is successful only to the extent that science can find a niche in the cognitive *and* socio-cultural milieu of students. Thus, the purpose of this research is to gain an understanding of high school students' fundamental beliefs about the world, and how their personal/cultural environments foster and support those beliefs. The methodology is ethnographic, involving the extensive interviewing of students. Active high school science teachers are intimately involved with the research as teacher-researchers.

> I use the term "scientific literacy" to denote the functional understanding of scientific concepts and the inquiring mental attitude that the school tries to develop... each individual develops a pattern for thinking about natural phenomena that may be called a personal natural philosophy... this natural philosophy reflects and perpetuates the prevalent cultural attitudes... Only in a small minority of students does the natural philosophy overlap substantially with modern scientific attitudes... (Karplus, 1963, pp. 837-8)

As seen in this 1963 quote of Robert Karplus, scientific literacy has long been viewed to include scientific attitudes and both the ability and willingness to use scientific information and thinking in everyday life. More recently these attitudinal goals have been reaffirmed by the AAAS' *Project 2061* and the National Research Council's *Fulfilling the Promise*, agencies of preeminent status in the American scientific community. The call for improved science education in 1963 was in response to Sputnik. In 1991, it is in response to America's failing economic competitiveness in world markets. It was then, and is now, a response to poor levels of science achievement and attitude among students. Attempting to improve the results of science education makes perfect sense, but there are significant obstacles. Very few students seem to take science seriously. How does one attract them to science? When students do study science and pass, how can we know that their attitudes and fundamental beliefs about the world have been influenced? In other words, how do we know that along with their knowledge their natural philosophies have been influenced? A number of years ago, a dedicated teacher wrote:

> In common with so many others, I used to think that we could get rid of... 'stupidities' by suitable talks on natural science... as if natural science could subvert [students'] traditional lore or philosophy. We destroy in this way their natural sciences, but their fundamental concepts concerning the universe remain *unchanged*... (Temples, 1959, emphasis added)

In recent years researchers have had a keen interest in scientific misconceptions and conceptual change. Temples noted from his experience that teaching science did not necessarily result in the literacy that science policy makers had in mind. I recently completed a study with nursing students that supports Temples' view that students can learn science without it significantly affecting fundamental views of reality. My study involved nursing students who had successfully completed a series of college science courses. Yet, in open interviews about the essence of the natural world these students showed little evidence of scientific thinking.

Listening to Students

The obstacles confronting more effective science education require that the philosophical background of science education be reexamined, but that is not the subject of our research at this time. The obstacles confronting more effective science education also require a greater understanding of how students understand reality. This is our basic research question. We have chosen world view theory to provide the terms or concepts needed for understanding someone's view of reality (Cobern, 1991).

Our objective is to map belief space or terrain of belief regarding nature, i.e., to map the qualitatively different conceptualizations of nature held by the students, including their perceived relationship to nature, and causality. Such conceptualizations are called outcome space by Marton (1988) and belief space by Jones (1972). The findings are descriptive categories and brief narratives derived from modified naturalistic inquiry (Lincoln & Guba, 1985), interview technique (Kvale, 1983; Spradley, 1979), and constant comparative analysis and grounded theory development (Strauss, 1987). The intention was to develop working hypotheses, in the form of interpretive statements, through an emergent design as advocated by Cronbach (1975), Lincoln & Guba (1985), and Strauss (1987).

It is possible that our questions could be approached with a naturalistic inquiry where students would be observed in a number of settings over a lengthy period of time. However, fundamental beliefs while having a wide range of influence, operate a quite subtle levels (Jones, 1972). It would take a very long time indeed to gather a relatively small amount of pertinent data. Thus, our choice of methodology is more direct. Our primary method for collecting data is the semi-structured interview. To encourage a person to talk at length about nature, relationship to nature, and causality, we use elicitation devices. Our current devices are not the only ones that could be employed in research such as ours, and not the only ones we will ever use. In principal, any device that elicits sincere responses to the issues of interest would do. Our particular devices are based on world view theory and informed by our historical studies of Western culture (Glacken, 1967; Merchant, 1983; Thomas, 1983). There is an etic perspective in our research. However, our perspective only serves to initiate discussion. We do not analyze data using etic codes. As much as is humanly possible, we allow the coding to come emmically from the transcripts.

The quality of the devices is directly proportional to device efficacy at prompting discussion on the issues in question. Nevertheless, within each elicitation device there is planned redundancy. If one aspect of a device is ineffective, a parallel aspect may be more effective. For example, the word sort in the first interview sequence contains several synonyms for several terms.

The data of our research is not a set of answers to questions. The elicitation devices are not measurement instruments. The data of our research is comprised of the text transcriptions of interviews. The spoken words of the informants in regard to the issues in question are our data.

We use three interview sequences. There is one each for the issues of the essence of nature, one's relationship with nature, and causality.

Interview Sequence #1: The Essence of Nature

Primary Interview: 45-60 mins.
Follow up Interview: 45-60 mins.

We wish to ask what is nature like. Is it knowable or mysterious? Is it orderly? Is it pleasant? Is it dangerous? To get a person to talk about the essence of nature, the interview involves three sorting/think aloud tasks. The words and statements are based on our studies of Western culture and represent perspectives of aesthetics, religion, order, control, and knowledge.

An interview begins with a focusing event. Informants view a set of naturalistic landscape photographs depicting nature at micro and macroscopic levels, including outer space, and nature as both benevolent and malevolent. After a few moments to examine the photographs, the informant is asked the grand tour question, "how would you define nature, that is, the natural world?"

Subsequently, three devices are employed to elicit conversation beyond what the grand tour question and photographs could accomplish alone. These involve three sets of words and sentences that related ideas about nature. The elicitation devices are structurally informed in that they are based on the view that conceptualizations of nature are rooted in the world view category NonSelf, and that in Western culture there are a limited number of ways in which nature has been and is now conceptualized (Cobern, 1991b). The structure in the devices partially overlap allowing the informants to be persistently engaged by concepts relevant to the issues, thus minimizing the potential for unrecognizable insincere comments. Overlap is built into the devices allowing triangular analysis of codes to improve the trustworthiness of interpretation. While thinking aloud, each informant sorts the words and sentences according to how accurately they corresponded to the informant's personal views. The interviewer, consistent with Spradley (1979) and Kvale (1983), is there to ask probing questions and to encourage the informant to speak freely and at length.

The First Interview - Task One

The first interview, completing task one, takes 45-60 minutes. It is designed to draw out student thoughts about concepts such as: what is nature like, the ability to know about nature, characteristics of nature, etc. The words chosen as prompts to elicit responses are based on studies of western culture and represent aesthetics, religion, order, control and knowledge. Words were also drawn from previous work with high school students. We have chosen our words from these categories in order that they prompt a wide spread of ideas.

The first interview begins with showing the student pictures depicting nature at micro-macroscopic levels. This is used to focus the student on the topic of discussion. We always ask if the pictures do or don't represent nature for them. Then we ask the "grand tour " question which is "what is your definition of nature or the natural world". We also try to find out if they see a distinction between the terms. Thereafter we use the term "nature".

After dividing the words randomly into three groups the student is asked to sort them into categories of either "nature is" or "nature is not". They then form subgroups of words which represent similar or related concepts. Students are asked to discuss their reasons for forming each group of words and how the group relates to nature. We continually ask probing questions to encourage them to speak at length and develop their thoughts. We do this by asking for examples, we play "dumb" and ask them to explain further. Depending on what we see in the word group we may pick out individual cards and ask for more information. Once they choose a direction we ask questions for more understanding. As students begin discussing the 2nd, 3rd, and 4th groups of words the interviewer may ask the student to relate the later groups to earlier groups. For example:

1st group	later group
chaos	knowledge order

The process is repeated for all words in both the "is" and "is not" groups. We finish by again asking the "grand tour" question - what is your definition of nature?

Task One Terms

Epistemological Description:

Reference to knowing about the natural world.

orderly	unpredictable	understandable
confusing	mysterious	changeable
predictable	knowable	unexplainable
		unchangeable

Ontological Description:

Reference to what the natural world is like.

material	beautiful	holy
living	dangerous	sacred
spiritual	chaotic	powerful
complex	diverse	matter
		pure

Emotional Description:

Reference to how one feels about the natural world.

peaceful
frightening
exciting
just there

Status Description:

Reference to what the natural world is like now.

full of resources
exploited
endangered
polluted
doomed
restorable

INTRODUCTORY COMMENTS WHEN STUDENT INTERVIEWEE ENTERS ROOM:

"Hi,"
"Have a seat,"
"Thank you for coming," etc.
"I think I have everything set up that I need except for your permission slip. Did you bring it with you?"
"I want to assure you that this is not a test. We are going to have a conversation about your concepts of "**nature**" for a study that is being done at the university."
"I'll be taping part of our conversation because I think we might be talking too fast for me to write everything down."

INTERVIEWER DOES

Spread out pictures and let student look at them

INTERVIEWER SAYS

"I've laid some pictures out in front of you, would you just take a moment to look at them?"

Pause

"How would you define `**nature**' or the `**natural world**'?"

Pause

"Is there any difference or are they essentially the same thing?"

(If a distinction is being made - combine them)

"Would you say that all of these pictures depict "**nature**"
or
are there some that **do** and some that **do not**?"

Put up signs
"**NATURE IS...**"
AND
"**NATURE IS NOT...**"

"We are going to go through a series of cards. I'm going to ask you to think about the words and then I'll ask you to comment about them."

INTERVIEWER DOES	INTERVIEWER SAYS
Divide cards randomly into three groups. Use 1/3 at a time. Lay out 1/3 of the cards.	
	"Remember, what we are focusing on is "**what nature is.**" I want *you* to divide these cards into two groups. One group of words that you would use when talking about "**nature**" and one group that you would not use."
Repeat for each 1/3 of the cards.	
Take words in the would use pile and spread them out in front of student.	
	"Some of these words may be about the same thing - do you want to lump any of these words together?"
Turn Tape recorder on if it hasn't been turned on yet.	
	"O.K., let's talk about these groups. Which of these would you pick out 1st to talk about "**what nature is?**"
Wait for student to pick.	
Repeat chosen words for tape.	
	"Fine"
	"What do these words have in common? Why have you put these words together?"
Ask clarification questions if necessary.	
	"Why are you saying `**nature is.....?**' What do you mean when you say `**nature is.....?**'"
Use either unifying concept or actual words in group for blank.	
	"In what sense would you say `**nature is.....?**'"

INTERVIEWER DOES	INTERVIEWER SAYS
Pull 1st group of words aside but keep them visible.	
	"Alright, we have this group aside now let's take a look at the rest. Which group would you pull out next?"
Go back through the question series.	
	"Why did you pull **this** group out after this group?"
Look for conflicting words	
	"Can you help me understand this? Why is it .... on the one hand and .... on the other?"
Try for 4 groups of "**Nature is**" then go to "**Nature is not.**"	

Tasks Two and Three

Task 2 and 3 are completed in the second audiotaped interview, also 45 - 60 minutes. Task 2 continues the discussion on nature utilizing sentences relating to nature instead of words. The sentences provide a significant amount of redundancy and also allow students to develop their ideas through sustained engagement with the topics. They also provide more specific prompts in some areas. This is done because some of the concepts can't be adequately represented by single words. We have some words that are religious words but the students often don't use them in a religious context. A student who rejected all the religious words in the first set as not applying to nature might pick up the sentence "i see in nature the work of god" as an important idea that they strongly agree with. While the first interview encourages students to explore a widespread of ideas, the second allows them to bring those ideas into more focus. In the 2nd task students are asked to group 18 sentences into one of two categories "agree" or "disagree". After this the interviewer follows the same format as used in task 1.

TASK 2: Statement Sort

The following statements are used in the same manner as the word sort elicitation task. Each statement is printed on a 3x5 card. The task begins by asking the informant to recall again his/her definition of nature. Two signs are displayed before the informant, "Agree" and "Disagree." The informant is shown all 18 cards and asked to divide the cards into two groups, i.e., those with which the informant is in general agreement with and against. The informant is then shown these two groups one at a time and asked to perform a ranking task. As the informant ranks the cards the interviewer encourages the informant to talk about his or her decisions. Probe strategy is same as in Task 1.

Epistemological Description

Knowable

1. Nature is something that should be studied so that we can learn more about it.

2. It is important to understand how things work in nature.

Unknowable

3. Nature is difficult to understand.

4. To me nature is mysterious.

Ontological Description

Super naturalistic

5. I see in nature the work of God.

6. I find in nature a spiritual quality.

7. Nature is the result of purpose and things happen in nature because of purpose.

Naturalistic

8. I view nature as something solid, substantial and reliable.

9. Nature is the material, concrete world around us.

10. The natural world is all there is, all there ever was, all there ever will be.

11. The material world of nature is the only real world there is.

Emotional Description

Positive

12. I see beauty in nature.

13 I have an pleasant emotional response to nature.

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Neutral

14. Nature is an everyday part of life that I generally do not think much about.

Status Description

Resource Orientation

15. Nature is a very important resource: water, energy, food, materials for making things.

16. Without the things that we get from nature we could not enjoy the lifestyle we have today.

Conservationist Orientation

17. I believe nature needs to be protected.

18. I am concerned about pollution and the damage it does to nature.

Task 3: Dyad Comparisons

The same sentences are used in task 3 as in task 2. In the 3rd task students are shown random combinations of 2 sentences. They are to retain the one that they most agree with and replace the other with another randomly drawn sentence. At this point they may choose to keep both sentences that were drawn originally if they strongly agree with them. This process is repeated until all 18 statements from interview 2 have been drawn. During the process the students are asked to keep the sentences that they have retained in rank order. Students have the latitude to reorder the sentences as they draw new ones. When all sentences have been drawn, they are asked to check the rank order of the sentences that they have retained. Although essentially a ranking task this interview also incorporates a think-aloud procedure. This affords the students one more opportunity to discuss the statements. The interview ends with a final question such as " can you tell me something that you know about nature that is quite important?".

Analysis

Transcription & Coding: Once the interviews are completed the audiotapes are transcribed. The transcripts are coded by assigning code words to chunks or pieces of the information within transcripts. Some of the code words were taken from the task 1 prompt words, others came from the transcripts themselves. The codes and definitions are kept in a lexicon so that they can be used consistently throughout the coding process.

Concept Mapping: Once the transcripts are coded, a computer program (*The Ethnograph*) is used to sort and then print text segments by code words. The computer printout for text associated with each code also lists codes in which the searched for code/text is embedded and codes embedded within the searched for code/text. This information is clipped together with the text associated with the searched for code. These clipped sets are then used for constructing concept maps. The research group works together to arrange the codes in the form of a concept map which represents the interviewee's conceptualization of nature.

Narrative: Using the structure provided by a concept map and content taken from the transcript the researchers write a 1st person interpretive narrative for each student. The process proceeds by copying the text under a code (e.g., order) into a file. Using as much of the student's language as possible, the raw text is worked into a coherent paragraph or set of paragraphs. This is done for all the code words used in the narrative structure which in turn was based on the concept map. The student interviewed then reads, edits, and discusses the content of the narrative with one of the researchers.

Assertions: Throughout the entire data analysis process we log any tentative assertions for later use. Then, using the concept maps and narratives we begin sorting, comparing, and cross-checking cases by major code categories to find consistencies and cross-group code differences. For example: we may divide them by gender, inclusion of scientific ideas, religious references etc. We also compare each of the main codes as identified on the concept maps. These comparisons allow us to make further tentative assertions based on all our cases.

We finally, as a team, reduce the total number of assertions by forming logical groups. Each group becomes an assertion with multiple parts. Then we cross-check each assertion against each case for confirming or disconfirming data. To establish a final list. A discussion of each assertion is written based on the 1st person narratives.

In order to ensure we that our interpretations have validity:

a) we use at least 3 elicitation devices allowing for triangulation of text code analysis.
b) a code is not used until the meaning of the chunk or lines is taken in light of the entire text and that it matches the definition of the code in the lexicon.
c) the process of coding one text after another proceeds iteratively. The lexicon grows with the addition of new codes and code definitions are refined.

d) coding is done by a caucus of two researchers and then is checked by a third. Finally the coded transcript is analyzed by all three together to iron out disagreements and it becomes a consensual agreement of the three.
e) we cross-check each assertion against each case for confirming or disconfirming data.
f) qualitative researchers not affiliated with this project cross check the assertions and discussions against the concept maps and 1st person narratives.

Summary Sheet of Individual Codes

Lines	Embedded In	Code	Co-Code	Embedded Code	Comments

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Example Page from Lexicon of Code Words

Inc/Exc	*Exclusiv*	people not included in nature
	Inclusiv	people included within nature
Knowable	*Decisions*	decisions about based on knowledge of nature (from Teacher2)
	Knowable	references to being able to know about nature, specific knowledge of nature, including references to inherent limitations of knowledge; explainable or the opposite, but implies that nature can be known
	Interest	nature is intellectually interesting (from Teacher3)
	Learn	specific references to learning about nature
	logical	nature is logical (from Teacher2)
	Matter	scientific use of term for substances, solids, gases, liquids.
	Myster	use of the term "mysterious" with respect to nature; not able to know about nature
	Predict	references to the predictableness or unpredictableness of nature
	School	references to, implications of (or inferences) school activities; eg, the researchers inferred that the comment wa based on a school lesson
	Science	specific reference to science or scientific knowledge, comments that most likely refer to scientific knowledge, eg, use of the words matter or cycle
	Scitist	specific reference to scientists
Natural Phenomena	*Animals*	references to animals or plants
	Gravity	standard definition
	NatPhen	general code for natural phenomena
	Quake	references to earthquakes; all geological disturbances or natural disasters
	Species	student used word
	Weather	specific references to weather
Order	*Balance*	"natural life living in balance, in perfect balance" ATG1N1
	Change	there can be change in nature; not necessarily chaotic change
	Cycle	used by student
	Order	references to order or lack of order in nature
	Organiz	used by student; organization in nature
	Pattern	used by student
	Reliable	reference to Nature being reliable
	Rule	used by student
	System	used by student

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Example Page of Coded Text

that you think. 771

SS2: Why birds, build nests right next 773
to your house. 774

ATG1: Why? 776

SS2: I don't know, why does the 778
weather have to be bad, I don't 779
know, something like that. 780

ATG1: O.K. How about confusing? 781
That might be easier one to 782
think about on a personal level. 783

SS2: Confusing, it's just like the bird 785
thing, again. 786

ATG1: Do you have a bird nest at 788
your house? 789

SS2: Yeah, well we just saw the bird 791
sitting right next to our fence, 792
too, so I really don't 793
understand that. Ahem, 794
confusing. The weather would 795
be very confusing because I 796
really don't understand it that 797
much. How clouds appear, I 798
mean by the barometer I would 799
say but, ah, that's about it. 800

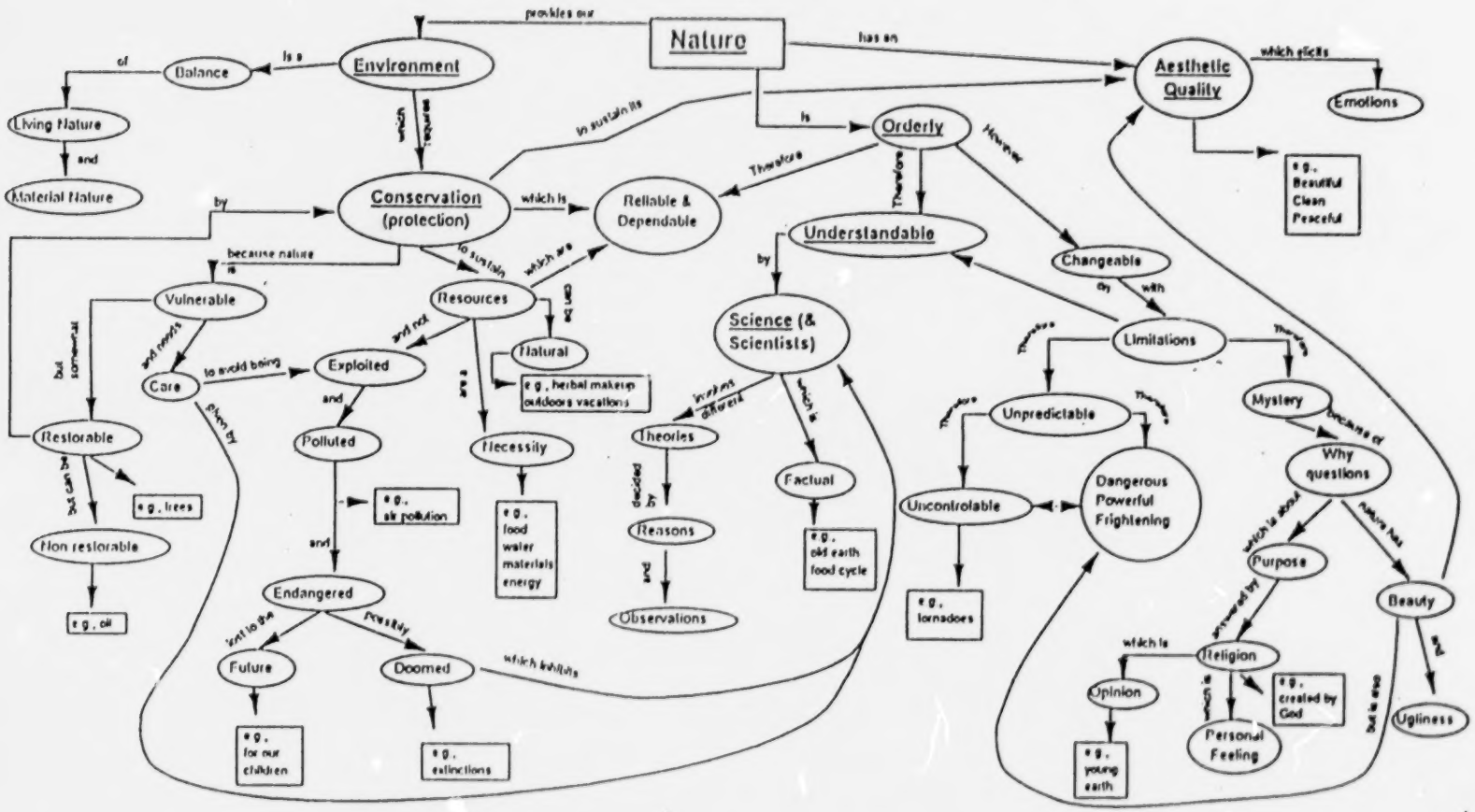
ATG1: O.K. Can you just wrap it up 802
and help me understand why 803
you put these 3 words together? 804

SS2: Oh, because they pretty much 806
mean the same thing to me. I 807
mean unexplainable, 808
unpredictable and confusing. 809
Because I mean these 2 kind of 810
link to this. I don't know, 811
every, they all kind of mean 812
the same thing to me. 813

ATG1: O.K. So is that your last word 815
on these words? 816

SS2: Yeah. 818

ATG.n1 - Final Map
3rd October, 1994



Example Concept Map

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Example Narrative for Example Map

How could someone say 'nature is just there' is beyond me because its everywhere. Nature is everywhere. It can't be something that's just there. We can't go a day without using something from nature. We depend on nature for everything: material items, resources, ideas and pleasures. If we as humans aren't careful we are going to ruin the one thing that we need to survive.

I see many sides to nature. It is material...full of resources: It is living...it can be hurt. I think nature is very dangerous: I think nature is very beautiful. It can be beautiful and peaceful but also dangerous and frightening. A tornado, for example, can be beautiful and mysterious in its power and at the same time ugly in the damage it can do. Nature has a predictable, understandable side to it, but also, an unpredictable, uncontrollable side.

I want to be a scientist. Nature is very important to the world of science. Through science we understand many of the patterns in nature; food webs, weather patterns, how the solar system works, etc. We need to know more about nature and we keep studying it to find out how things work and to discover ways that different things affect each other. However, while science can work to increase our knowledge and understanding of nature, it is all people in the world that must act responsibly to help solve the problems we've created in nature. It will be hard for scientists to study nature in the future if we just keep destroying it.

We use a lot of material that nature gives. Nature is full of resources ...rocks, chemicals....gas, oil... trees, animals....and air and water." Exploitation is a problem. It is frustrating that many people, except scientists, don't care. Not all of the problems are correctable. Although nature is somewhat restorable, once plants and animals are extinct that's final. Is nature doomed? Yes, possibly! For lack of caring!

I'm not sure about the connection between God and nature. While I am a Christian I also believe that science has proved wrong, many of the things in the Bible. Yet I do think that there is a purpose for our existence and God is behind it. Science can explain how things work but there are many "why" questions that science doesn't answer. I have a very strong response to nature. I'm one of those people that is always thinking about nature in everything I do or want to do. While I see beauty in nature and that is very important to me I think it is far more important that we put out thoughts towards protecting nature at this time. My own personal enjoyment is secondary to that need. "Because nature is so important to us, it is sacred. We have to have it to live. That's kind of a big deal."

Interview Sequence #2: Relationship with Nature

Primary Interview:	45-60 mins.
Continuation of Primary Interview:	30 mins.
Follow up Interview:	30 mins.

We are basically asking 1) to what extent people see themselves as a natural part of nature; 2) whether or not people are perceived as being qualitatively different from other aspects of nature; 3) to what extent, if any, control over nature by people is appropriate. The interview description given for the first interview sequence applies here as well.

An interview begins with the grand tour question, "If there is any kind of order in the world, where do people fit in that order?" The informant's response is followed with three elicitation devices.

Card Sort and Label

The object here is to gain insight into the informant's view of the relationship between people and other aspects of nature. The informant is shown forty 3X5 cards each with an image from nature. There are five images per each of the following groups:

a. Physical geography: mountains, ocean, beach, river, rocks, sky.
b. Mammals: people.
c. Mammals: various large and small mammals, including sea mammals.
d. Birds
e. Fish
f. Insects
g. Reptiles
h. Plants: trees, bushes, and flowering plants

The cards are mixed and the informant is asked to sort them into whatever groups desired, thinking aloud as s/he does so. The informant is also asked to give each group a label or name. The informant is then asked if there is any arrangement of the groups that s/he finds particularly meaningful. The arrangement is noted by the interviewer.

Once finished the informant is asked if any of the groups can be combined to make a larger and more general group. Again, the informant thinks aloud.

People vs Nature

The objective here is to gain insight into the informant's valuation of nature. Do we protect it all costs? Is it there for our use? Are there special circumstances that allow use that otherwise should not be tolerated?

The informant is shown four passages that describe an intended action (fictitious or quasi-fictitious) against non-human nature, the reasons for the action, and the probable consequences for people and non-human nature. The informant is asked to decide whether the action should go forth and why? The passages below are typical of what we use. There are more kept as backups in the event that an informant has little to say about one or more of the first passages presented.

1. The California condor is a large bird that was near extinction a number of years ago. The last wild birds were captured by scientists and raised in captivity. Now the scientists have raised enough birds so that some can be returned to the wild in a remote area of California. However, monitoring the birds to insure that they survive in the wild will cost $1.5 million per year for the next 20 to 30 years. The public must decide if saving the condor is worth this great expense.

   What are the important factors? What difference does the amount of money make? Does the kind of animal make a difference?

2. Scientists at a university are planning to build a new observatory. This is a building with telescopes needed for observing stars, planets, and other things in the night sky. The problem is that a particular type of squirrel lives where the scientists intend to build the observatory. The observatory may ruin the squirrels' natural home. If it does, this type for squirrel will die out. The public must decide whether to support the observation project or to help save the squirrels.

   What are the important factors? Would it make a difference if the science was of another type? For example, medical research? Does the type of animal matter? What if it were some type of insect?

3. Medical scientists are working on a cure for various diseases. Their experiments require the use of rabbits. The rabbits do not suffer pain in the experiments, but they do die. There is a group of people who feel that experiments with animals are wrong. They are trying to pass laws that would prohibit animal experiments. Would you support such laws?

   What are the important factors? Would it make a difference if the science was of another type? For example, something that was non-medical? Would your views change if the experiments were done with a different type of animal? For example, rats.

4. A resource can be used only by destroying the immediate environment in which the resource exists. At this point we must assume the damage will be permanent but it can be confined to an area of several miles. The resource is vital to the maintenance of nearby jobs. Should we close the resource plant because of environmental damage and sacrifice the jobs? Should we sacrifice the local environment so long as the damage can be contained?

What factors are of importance? Does the number of jobs make a difference? What if one of the jobs was yours? What if the resource was vital to the cure of what otherwise would be a terminal illness?

Important Contributions

The object here is again to gain insight into an informant's valuation of nature. Here, however, the informant is faced with both nature-oriented and nature-neutral descriptions. Further, the nature-oriented descriptions involve three different perspectives on nature.

The informant is given a hypothetical situation. The president is going to give an award for an outstanding contribution to our society. Ten people have been nominated. The informant is asked to rank the people from most deserving to least deserving of the group. As always, the informant is asked to think aloud. Once finished, the informant is asked whether there is any situation in which s/he would change the rankings. Nature oriented and nature neutral descriptions are represented in approximately even numbers (6 to 5). The nature oriented descriptions are divided between nature as resource, knowledge of nature, and ecology.

Nature neutral:

1. This person has helped many people, from ordinary citizens to company presidents and politicians, to understand what it means to take the right, moral, and ethical action regardless of personal consequences.

2. This person has helped many people, especially families, to get along with each other and to help each other. This person has improved the home life for countless numbers of children.

3. This person founded a business that created many jobs and helped to save a city that was withering away due to unemployment.

4. This person helped a city to solve some very difficult problems of racism and poverty.

5. This person wrote a piece of music that has brought pleasure to people all over the country.

Nature as resource orientation:

6. By studying tropical plants, this person has found the cure for a terrible disease.

7. This person invented a new procedure for extracting resources from the earth. These resources are crucial for the manufacturing of items, from cars to radios, that improve our quality of life.

Knowledge of nature orientation:

8. This person has made a major discovery that helps us to understand the extremely small particles that make up all matter. Scientists consider this one of the most important discoveries of the 20th century.

9. This person has made a major discovery in the heredity of animals, that is, a discovery having to do with how traits in the parents are passed on to the offspring. The discovery solved a problem that has puzzled scientists for 50 years.

Ecological orientation:

10. This person has made a major discovery concerning the influence of people in cities on the forests and grasslands around a city, and the influence of the forests and grasslands on the people. Because of this person's work, cities all over the nation are establishing "greenbelts" in and around populated areas.

11. This person has helped thousands of people to understand that people are a part of nature just as much as birds and deer, mountains and deserts are a part of nature. This person has brought about a significant change in peoples' attitudes about nature.

The interview sequence ends with two follow up questions:

What does it mean to be human? To be a person?
Are human beings animals? Explain.

Interview Sequence #3: Understanding of Cause

Primary Interview:	45-60 mins.
Continuation of Primary Interview:	30-45 mins.
Follow up Interview:	30 mins.

Our approach to causality derives from the contention that a scientifically compatible world view must include presuppositions in the Causal universal that are appropriate to scientific explanation. Obviously, there are many ways one can understand explanation. For our purposes we use Pepper's (1942) root metaphor theory which essentially says that explanations can be understood as examples of six metaphors: animism, mysticism, formism, mechanicism, contextualism, and organicism. Science textbook explanations are typically formistic/mechanistic. The intent of the interview is to give informants a chance to talk about explanations that are personally meaningful.

Preferred Explanation Style

The primary problematic feature of any discussion of explanations is that the interview itself must not be appear to be a test of scientific knowledge. Ignorance of scientific concepts does not necessarily indicate fundamental beliefs antithetical to science. We, thus, make the following assumption:

> When a student is faced with an unfamiliar phenomenon, he or she is more likely to accept an explanation that is more consistent with his or her world view than an explanation of the phenomenon that is less consistent.

If one presents a student with an unfamiliar phenomenon and two explanations, one cast in a scientific style (formistic/mechanistic) and the other not, one would expect students with scientifically compatible beliefs to choose the first explanation more frequently than students with variant beliefs. This suggests that an interview be structured with *unfamiliar phenomena* as items for discussion.

Unfortunately, one can never be sure who is familiar with what. An alternative procedure that avoids this problem is to create descriptions of fictitious or quasi-fictitious phenomena. For the current study we use 17 such descriptions with several others for backup purposes. An informant is told that the descriptions are not necessarily factual and that the interview is not a test of knowledge.

We assume that presuppositions amenable to scientific explanation are present in a student's world view if a student frequently chooses explanations that are scientifically compatible. Thus a scientifically compatible explanation is needed for each description. Obviously the explanations for the fictitious phenomena are also fictitious. The explanations for the obscure phenomena items also are fictitious in order to avoid confounding affects of students who might happen to be knowledgeable about the obscure phenomena. The criteria for designing a fictitious, but scientifically compatible explanation is from Pepper (1942), Braithwaite's *Scientific Explanations*, and to a lesser extent Aicken's *The Nature of Science*.

To be acceptable in science an explanation must be empirical and above all, testable. A scientific explanation always involves natural causes and tends to be mechanistic and reductionistic. Thus the scientifically-more compatible explanations were designed to be:

1. natural
2. rational
3. mechanistic/reductionistic
4. hypothetical/deductive
5. experimental
6. epistemologically dynamic/tentative.

Any scientific explanation is also a part of a theoretical structure or system composed of many explanations, generally on different levels of explanatory power. Scientific explanations are not given in isolation (Martin, 1972), however with the exception of one description that relates experimentation to theory, all of the descriptions contain ad hoc explanations. The notion that explanations should be related to other explanations in an explanatory system is not unique to scientific thinking however, and thus was not included as a criterion for the description in this interview.

The foil in each item was a rational explanation designed to be scientifically-less compatible or simply scientifically unacceptable. The criteria for composing such explanations were basically the opposite of the criteria for designing the scientifically-more compatible explanations. An attempt was made to write rational explanations that were holistic rather than reductionistic, plausible though non-testable. None of the explanations used in the interview is scientifically compatible because all are fabrications. However, it can be argued that when the explanations are considered hypothetically some are more compatible with science than others.

SOPE ITEM 1

Some people were observing a demonstration that involved a miniature red train car, a bit of track, and a tunnel. When the demonstrator pushed the train car into the tunnel a blue car came out the opposite side. When the blue car was pushed back into the tunnel the red car reappeared out the other side. People suspected that there were really two cars, originally the blue one being hidden by the tunnel.

To test this idea they listened carefully when the red car was pushed into the tunnel feeling sure that they would hear it knocking the blue car out the opposite side. Try as they might, they could hear no sound of a collision. The people then fell into two groups over the matter:

A. Some people found the demonstration intriguing and amusing. They considered the demonstrator to be a kind of magician who was proving that the hand really is quicker than the eye.

B. Other people recalled that like-poles of magnets repel each other. So perhaps there were two cars each with a magnet. Like poles faced each other so that one car entering the tunnel drove the other out without ever touching.

Which explanation would you be more willing to accept?

SOPE ITEM 2

The following paragraph was taken from a newpaper article:

A man today died in a car crash. Unfortunate though he was the crash itself was typical of many fatal accidents. The one peculiar thing about this incident was that last night the man dreamed about a serious car crash. This morning he told his wife about it but did not seem unduly concerned.

The following are reactions people have had to this event. Which reaction is closest to how you feel about this news story?

A. The man should have paid more attention to his dream. Then he would have been more careful and might be alive right now.

B. It was just coincidence that the man who died dreamed about a crash the night before.

Which of the above two explanations concerning the car crash and dream would you be more willing to accept?

SOPE ITEM 3

There once was a woman who to put it mildly drank a great deal. Every day after work she would begin going from bar to bar until late in the night. Hardly a day would pass that she did not end in a state of intoxication. People said that this was not even the worst of her moral degeneracy, but that she was as well a cruel and spiteful woman. She seemed to delight in unkindness. One morning she did not come to work and later it was learned that she died the night before of a heart attack. Her colleagues at work spent much time that day discussing her fate.

A. As the doctors said she died of a heart attack. She undoubtedly put too much physical strain on her system and her heart finally gave way.

B. She was a young woman who should have had many years ahead of her. She was however decadent and mean, and an untimely death was the consequence.

Which of the above explanations would you be more willing to accept?

ITEM 4

Occasionally when entering a room for the first time one gets the distinct impression that he has been there before. This impression can be very strong and disturbing, and all the more because one is sure that he has not ever seen the room before. There seems to be two reasonable explanations for this phenomenon:

A. This is an example of deja vu which is something almost all of us experience from time to time. It is remembering a place you had never been to before or an object or person you have never seen before. This phenomenon is a reminder of the vast complexity of the human mind, a complexity of which we understand very little. What we understand least is the capacity of the mind to perceive things outside the range of our basic physical senses.

B. The human brain is a complex electro-chemical computer. Although for the most part it functions faultlessly there are occasional lapses. The above is such a case. After the first glimpse of the room there is an instantaneous functional lapse and recovery. The lapse causes the initial glimpse to be separated from the current perception of the room. The result is that the initial glimpse becomes like a memory. One is deceived into thinking that he has seen the room before.

Which explanation would you be more willing to accept?

ITEM 5

Two men had a severe quarrel one day. One of the two filled the air with profanity and cursed the other man. He felt that he had been cheated and vowed to get back at the other man. The second man hardly knew what to do and was overcome with worry. Although the two men never met again the second man became very ill shortly after the quarrel.

A. Worry has, as do most strong emotions, a physical affect on a person. It causes acids to flow in the stomach which eventually can lead to an ulcer. This is likely what happened to the second man.

B. The curses and swearing of the man made a deep impression on the second man. The curses altered that man`s thinking and ate away at his physical health. Unless there was a reconciliation between the two the curses would continue with their effect.

Which of the above explanations for the man's illness would you be more willing to accept?

ITEM 6

The idea of evil spirits is a common one. At various times this idea has existed amongst virtually all people of the earth. Even today there are many who would attest to the reality of evil spirits. The fact that this idea has historically been so universal has led some anthropologists to ask how this idea came about. Could it be that the idea is so common because there actually are evil spirits? Both of the following opinions are held by experts:

A. Let us take an example of a so-called evil spirit. In the past people who behaved abnormally were said to be possessed by evil spirits. We now know that abnormal behavior or mental illness is caused either by the inability to cope with the pressure of the environment in which the afflicted person lives or by a chemical (e.g. hormonal) imbalance in his brain. All events said to be evidence of evil spirits can be similarly be explained by the advanced knowledge of today. There are no evil spirits. The collective experiences of so many people should not be ignored.

B. It could be that there are entities of beings which are commonly identified as evil spirits and are the cause of many unusual events, but about which we know nothing at all. However as curious as one might be about the subject, by its very nature it is unknowable. The rules of critical thought ultimately get us nowhere in this matter.

Which opinion would you be more willing to accept?

ITEM 7

Two men became tired of working for their living so they decided to rob a bank to make themselves rich. They took guns, went to a local bank and demanded all the money. An alert policeman saw what was happening and intervened. The robbers fearing capture fired their guns. In the confusion they managed to escape in a stolen car leaving behind several injured and dying people. By this time the robbers were panic stricken and raced down the road at a very high speed. On a curve the driver lost control of the car and both of them died in a ghastly accident. Amongst the people who read about this incident in the newspapers there seemed to be two feelings about why these robbers died:

A. Why did these men die? We may be glad that they did die being so evil. The "how" however is more simple. Their evil deed was poorly planned. Had they carefully thought it all out ahead of time they either would have abandoned the idea or would have developed a much less reckless plan.

B. Sometimes we look around and see the evil that people get away with, and we think to ourselves, "There is no justice." But often there is justice and here is a good example. These men willfully decided to do evil. Why did these two die? It was the just price of their evil.

Which explanation do you find more acceptable?

ITEM 8

Two people were walking on the beach when one turned to the other and said, "Do you know that no two grains of sand are exactly alike?" The other asked how he could possibly know. The first person said, "I proved it. I spent all last year examining 10,000 individual grains of sand using a microscope and a sensitive scale. There were not even two that were alike." The other person had two thoughts about this proof:

A. 10,000 grains is a very large sample. There could only be the remotest chance that any further investigation would have a different result. For all practical purposes the assertion is proved.

B. This is not proof at all. He has certainly corroborated his assertion but he would have to examine all grains of sand to have proof.

Which position would you be more likely to accept?

ITEM 9

Outside of a rural town there is a bog, that is, a wet, swampy area. Sometimes at night a peculiar phenomenon occurs over the bog. Especially on still, windless nights one can sometimes see hundreds of flickering lights all over the bog. Two explanations have been put forward to account for these lights:

A. In the past people claimed that these lights were the evil spirits that lurked in the bog. Of course we do not believe such things today. Still we are surrounded by events such as this one which we find difficult to understand and explain. We will not call these lights spirits, but we may find that our imagination conjures up images of strange creatures which lurk at the periphery of our physical senses.

B. In such boggy areas one often finds the natural occurrences of sulfur dioxide gas. This volatile gas when allowed to accumulate will often combust spontaneously. This is just what happens over the bog on windless, still nights, resulting in the appearance of flickering lights.

Which explanation would you be more willing to accept?

ITEM 10

Reports from a recent space flight indicate a new material has been identified in outer space. Although insensitive to the presence of ordinary matter, when approached by a human being it glows brightly in a variety of colors.

A. It has long been suspected from other evidence that human beings give rise to psychic emanations, but the main difficulty has always been the development of a suitable detector for this influence. This new material appears to be an ideal detector for it is sensitive to human proximity as well as operating over a wide range of personality types.

B. The new material is composed of atoms which are sensitive to the heat radiation emitted from human beings. This radiation excites the planetary electrons of the material`s atoms. When these electrons return to their ground state they emit light radiation which is determined by the distance between one atom and the heat.

Of the above two explanations which would you be more willing to accept?

ITEM 11

A recent spaceflight to a distant planet in another solar system finally answered a long-standing question. Is there life else where in the universe? Several indisputable life forms were found on this planet. Now, the surface temperature on this planet is extremely high, much higher than could be stood by earthly creature. To cope with the extreme heat it was found that most of the creatures on this planet had as an outer covering a layer of ceramic-like scales. Remarkably these scales are much like the heat resistant tiles used on some spaceships. The origin of these strange creatures is of interest to scientists, but of especial interest are these ceramic-like scales. There are two explanations:

A. The final cause in the universe is the Creator, or some might prefer a creative force. This Creator in designing the universe has built into creatures the potential for developing and evolving structures that allow them to live in even the harshest of environments. In this case the design has allowed the development of heat resistant scales which are remarkably ceramic-like.

B. Evolutionary theory adequately covers the matter. These creatures could not survive the harshness of their environment if they did not have a protective coat. They thus evolved these scales which allow them to withstand the extreme heat of their planet.

Of the above explanations which would you be more likely to accept?

SOPE ITEM 12

Recently astronomers have observed an increase in radio wave activity of particular frequency from a particular sector in the sky. This observation has caused a stir and a great deal of speculation as to its explanations. So far there are two explanations that the astronomers are arguing most about:

A. Man has often doubted that he was alone in this vast universe. These radio waves might well be radio signals from some far civilization upon which we have stumbled or indeed they may even be meant for us.

B. There are many physical bodies in the heavens which emit radio waves. These emissions fluctuate and chances are these new emissions will be found to fall within the regular pattern of chance fluctuation.

Which of these two explanations would you be more willing to accept?

SOPE ITEM 13

In the past when a man's heart stopped beating he was declared dead. Now medical doctors have the technology to restart a man's heart if they act quickly enough and thus to bring him back to life. A curious result of this is that we are now receiving interesting reports from these patients who have "died" but have been saved by this new technology. These reports are about the experiences these people have had during the minutes when their hearts were not beating. They claim that during that time they experienced the afterlife, that is the life that many people believe to be waiting for a person after he dies.

There have been two reactions to these claims:

A. The dreams of a sleeping man are due to various electro-chemical processes in the brain. When a man's heart stops beating these brain processes do not immediately stop as well. His mind may still be dreaming since it takes time for this electro-chemical activity to cease. If the doctors are able to revive a man's heart, then when he regains consciousness what he remembers are only dreams like any other.

B. We may say that a man has died when his heart stops beating. What we really should say is that his body has died. The spirit of the man still lives just as the philosophers have so often taught. The reports from these people who have died and then been revived give us the first empirical evidence that the spirit of a man does not die with his body.

Which explanation would you be more willing to accept?

SOPE ITEM 14

There are many people engaged in the scientific study of teaching for the purpose of improving teaching. This prodigious effort includes observations, experiments, statistical analyses and consumes large sums of money and time. The experts however, disagree about the worthiness of such efforts. Some are in favor but others are opposed.

A. It is all for the most part futile. We may gain in the understanding of teaching; but that understanding cannot be reduced to propositions and skills which can then be taught to students so as to produce good teachers. It cannot be done anymore than one can train someone to be a good artist. Both require talent. If you have talent then lessons based on sound studies of teaching will help you to develop that talent. If there is no talent then no amount of study will help.

B. The critics of educational research are put off by the difficulty of the task; but being difficult does not mean it is impossible. If that were the case physicists would have given up on the atom long ago. Teaching is a complicated activity but it is also one that is subject to observation, manipulation and experimentation. Therefore we can expect that diligent and creative research will eventually tell us much about teaching and how to train good teachers.

Which position would you be more willing to accept?

SOPE ITEM 15

B.F. Skinner has created much furor with his ideas on human and animal behavior.

A. Skinner claims that the ability to explain and control human behavior is limited at present because we hold on to the idea of a "person" or "self" which although it claims to be responsible for human behavior cannot be analyzed by the methods of science. He argues that if we were to get rid of the idea of a "person" controlling behavior we could treat man's behavior as just another example of animal behavior.

B. Skinner's opponents agree that a wide range of human behavior can be analyzed by the methods of science. They go on to claim however that there are certain fundamental areas of human experience e.g. belief, volition, consciousness, which only make sense if we retain the concept of a "person" in control of and responsible for his or her own behavior. Since this "person" has created the science he has applied to his own behavior, his nature must contain more than can be analyzed by this science.

Which explanation of human behavior would you be more willing to accept?

ITEM 16

Often drawings are found in the caves that once served as shelters for ancient, primitive men. These drawings are usually lifelike, obviously depicting things and events in the lives of these people. Sometimes the drawings are quite puzzling. For instance in one cave there are drawings of buffalo leaping over what appear to be trees!

There are two possible interpretations of this picture:

A. Obviously there has been a misrepresentation of what is really shown in the drawings. Even the largest buffalo cannot leap over trees unless the trees are exceedingly small ones. The depiction is probably of some type of bush that resembles a tree; perhaps one that is no longer found in the area.

B. The buffalo is a mighty animal; even more so to primitive men who hunted them with stone age weapons. These cave drawings are works of art which figuratively portray the buffalo's strength by picturing him in an impossible task. The impossibility of the feat emphasizes the admiration these people had for the buffalo.

Which explanation would you be more willing to accept?

SOPE ITEM 17

In a remote mountainous area some petrographs were discovered on a large protruding rock. The drawings were very old and included arrows pointing in various directions, star shapes and spiral shapes. Who drew them and what do they mean? Anthropologists have found that they were a nomadic group who lived for hundreds of years in this area and then vanished. As to what these drawings mean, that is much less clear. Two quite distinct explanations have been advanced:

A. We know that ancient men were often observers of the heavens. From their observations they were able to time planting and harvesting, as well as nomadic movements. These newly discovered figures are probably the records of some ancient astronomer's observations and sightings.

B. These drawings are works of art. We need look for no further purpose than to say that they are an expression of a people`s emotions and aspirations. We do them an injustice when we do not allow them an art for art's sake alone.

Which of the two explanations would you be more willing to accept?

SOPE ITEM #18

In many areas of the world today the health of the people is looked after by traditional and herbal medicine practitioners. These traditional physicians practice a healing art based on generations of accumulated knowledge. In spite of this, the modern study of medicine does not include any areas of this traditional knowledge. Recently doctors concerned about this issue have divided into pro and con groups:

A. The study of modern medicine is the study of western medicine. This should tip us off to the real reason behind the resistance to the scientific study of traditional herbal medicine. It is pure and simply western chauvinism. From the scientific point of view there is no reason for not carefully researching well-documented traditional cures. The findings would benefit all of mankind; and in addition there would be a greater appreciation of the traditions of non-western peoples.

B. Modern experimental medicine has been successful largely because it is directed by rational theory. The theoretical structure of a science tells the investigator which avenues of experiments are most likely to be profitable, thus avoiding many deadends. Since there is no such structure in traditional medicine a researcher would be left to follow dozens, even hundreds of nebulous accounts of "cures that work." Such ad hoc experimenting is wasteful and inefficient. It is for this same reason that "home cures" that so many families use are not pursued by researchers.

Which position would you be more willing to accept?

SOPE ITEM 19

A startling discovery has recently been made amongst a pre-modern group of people in a remote region of the Amazon Basin. An anthropologist living with these people for a year noted that the council of elders had a perfect record on predicting rainy days. Out of 365 days there were 109 days on which rain began to fall. All of these days were correctly predicted two to four days in advance. For the same period of time the government meteorological forecasts were much less accurate. The elders based their predictions upon the pattern made by dried chicken bones which they would cast a specific number of times each day. The scientist was impressed with the accuracy but skeptical that the bones had much to do with it. He got the elders to cooperate in a number of experiments by which he hoped to determine the real nature of their predictions. None of his hypotheses were confirmed, all were rejected. In the end he was convinced that the predictions must indeed rest upon the chicken bones. Later the anthropologist reported his findings at the symposium; and although his peers agreed with his conclusions they disagreed in their reasons:

A. Pre-modern people although pre-modern are still clever. They skillfully put to use the collective observations and knowledge of their ancestors, as in this case. Modern people are surprised by their achievements only because they think of the pre-modern man as naive and unintelligent.

B. First of all the anthropologist's studies were rationally designed and carefully conducted. Secondly, his findings are corroborated by the work of other anthropologists amongst other types of people. Thirdly, chemists have recently found that dry bones absorb moisture from the air and that the amount of "bounciness" in the bone depends on how much moisture has been absorbed.

Which side do you find more acceptable?

ITEM 20

Pea seeds when passed through a magnetic field germinate faster than seeds which are not passed through a magnetic field. There appears to be two logical explanations for this:

A. The magnetic field has an effect on the pea seed chromosomes. This results in faster cell division due to the pre-alignment of the chromosomes by the magnetic field. The seeds therefore germinate quicker.

B. After fertilization there is a principle of life which begins to drive the growth process. At an early stage that principle can be stimulated and quickened by many outside forces such as a magnetic field.

Which explanation would you be more willing to accept?

SOPE ITEM 21

When plant seeds are grown in small pots it is possible to quicken their growth rate by periodically shaking the pots. This "shaking effect" is poorly understood but there are two schools of thought on the matter:

A. The roots of plants use up first the nutrients in the soil which are closest. The result is that the amount of soil nutrients increases with distance from the roots. Shaking stirs up the soil and helps bring richer but distant soil into contact with the roots.

B. All living things benefit from an occasional but gentle stirring up of their environment, and even of themselves. It gets the juices, fluids and chemicals moving and flowing. It provides fresh air and removes the stale. It encourages, one might say, the processes of life.

Which explanation would you be more willing to accept?

SOPE ITEM 22

Bird migrations are an interesting phenomenon. For instance some geese can fly thousands and thousands of kilometers from one point on the earth to another never getting lost. This remarkable feat of navigation is of great interest to biologists and also controversial.

There are two much debated explanations:

A. Some biologists view bird navigation as a kind of natural movement. For instance, humans, can both walk and crawl; but they always walk because that is what is natural for them to do. It is possible for geese to fly in the wrong direction but that would be like humans crawling. They do not do it because it is unnatural.

B. Some biologists are quite convinced that wind currents act like Coriolis forces on the birds. The geese are sensitive to very slight variations in wind force and direction. By instinct they react to these variations and thus maintain their course.

Which of the two explanations would you be more willing to accept?

SOPE ITEM 23

Is it logically possible for a system to explain itself? It appears to be a tautological dilemma since to explain itself a system can only explain the system in terms of itself. For instance is it possible to know how the brain really works since any theory put forward is a product of the human brain? The dilemma seems very discouraging yet scientists are undeterred.

A. The key to understanding any system, no matter how complicated, is in its parts which are necessarily less complicated than the whole. By examining and experimenting with the parts we eventually will learn enough about the whole brain to enable us to restore all neurological disorders.

B. Science has enjoyed great progress in understanding natural phenomena and scientists as a result have come to take progress as a scientific right. They have lost sight of the fact that all human endeavors including progress are limited and unending progress is not to be expected. If neuro-scientists were to remember that then their present viewpoint on the human brain would certainly be more humble.

Which of the above positions would you be more willing to accept?

SOPE ITEM 24

Recently neuro-scientists studying the human brain have found particular areas that "specialize" either in multiplication or division. Now we know that multiplication is just the reverse of division yet for the brain that does not seem to be so. There appears to be a separate, unique center for each. This brings about an interesting suggestion. Thanks to the Babylonians man has been doing multiplication and division now for 6000 years. Given that man has been on this earth for a million years, does that then mean that those parts of the brain sat around unused for 994,000 years until multiplication and division were invented by the Babylonians?

A. This is a straight-forward matter of logic. If there are sections of the brain that do only multiplication and division, and these processes were invented 6000 years ago, either the sections have existed since the first man but were unemployed until the Babylonians; or those sections were a recent neural development at the time of the Babylonians.

B. This is indeed an interesting suggestion but one that is completely untenable. We must reject it and wait for a more testable hypothesis. In the meantime we can only accept the ambiguity with which we are faced.

Which of the above explanations would you be more willing to accept?

SOPE ITEM 25

Many people enjoy having plants in their homes. Some of these people also enjoy music and like having it as well in their homes. Recently in a very curious study it was noted that house plants grow better in homes where music is frequently played. This discovery has precipitated two opposing views:

A. There is nothing in our knowledge about plant growth that would cause one to suspect there to be any relationship with music. Thus, this phenomenon is most likely the result of careless or poor research procedures. Before it could be taken seriously this phenomenon would have to be very well documented.

B. One thing is certain and that is that not all who keep house plants are equally diligent in the care of their plants. It could well be that it is the music lovers who are the more diligent thus accounting for the correlation of plant health with music. It would be in keeping with the nature of a music lover to give special care to house plants for like music the plants are alive and beautiful.

Which of these explanations do you find more acceptable?

SOPE ITEM 26

People often wonder when confronted by the human-like characteristics of chimpanzees why they have not evolved the ability for language and speech. Opinion on this issue is divided:

A. The thoughts and emotions of a chimp are simple, lacking complexity, and can be communicated to another chimp by simple means, e.g. gestures. On the other hand an elaborate capacity for speech is required by humans because of their equally elaborate structures of thought and emotion. Simple means of communications would just not be sufficient.

B. Appearance can be deceiving as in the case of human-like characteristics of chimpanzees. The primary distinction between other animals and human beings is the "humanity" of man which is composed of such abilities as speech and rational thought. Without "humanity" man would indeed be just another animal.

Which explanation would you be more willing to accept?

SOPE ITEM 27

The science column in a newspaper ran a story about physicists working with electricity. Their findings have completely undermined the present understanding of the nature of electricity. The newspaper article concluded that electricity just is not what we thought it was nor does it work the way we thought it did! People have reacted differently to this article. Some believe it, others do not.

A. It is not likely that the newspaper reporter got his facts correct. The nature and workings of electricity are well understood by scientists. Our lives are filled with electrical gadgets like light bulbs and telephones which prove that our knowledge of electricity must be pretty accurate.

B. This article could possibly be correct. There are many things that yesterday`s scientists knew to be correct yet today we know them to be incorrect. Even a theory as well supported and articulated as that of electricity is susceptible to revision and even drastic change.

Which explanation would you be more willing to accept?

SOPE ITEM 28

goal that geologists have long had is to acquire enough knowledge about earthquakes so that they can be anticipated hours or even days in advance. Now it has been discovered that many animals can do just that. The geologists are still unsure about just how a particular animal senses a quake coming but there are two theories:

A. There are many things in the environment that animals sense such as danger or changes in the weather. This is an ability that modern people have lost due to their remoteness from nature and reliance upon technology.

B. It has now been learned that there are slight almost imperceptible pre-tremors that come hours, sometimes days before a major quake. These pre-tremors are noticed by animals, particularly grazing animals, which then become quite nervous.

Which of the above explanations would you be more willing to accept?

SOPE ITEM 29

Certain planetary bodies appear to deviate slightly from their calculated position in space. The deviation is extremely small. Everyone working in this field agrees:

a. That the deviation exists, and
b. that Relativity Theory offers the most likely explanation.

When asked why they supported this explanation workers gave different reasons:

A. It is difficult to make accurate measurements and existing experimental evidence lends only weak support for the theory. Nevertheless, the evidence gives better support to this theory than to any other.

B. The explanation was published by one of the most distinguished scientists of the 20th century. There is no doubt that he knows more than anyone else in the world about this particular phenomenon.

Which explanation would you be more likely to support?

SOPE ITEM 30

A physicist at a well known university was conducting a unique set of experiments. He was interested in the effect of electrical discharges on the growth rates of a particular type of tree. The methodology was simple. He administered electrical shocks to one set of trees but not to second. Over a period of several months he measured and compared the growth rates of the two groups. The scientist's work caused a stir amongst his colleagues because he admittedly had no theoretical framework for his research. There were two basic opinions about this kind of experimentation:

A. The highly theoretical nature of physics provides an ample number of research problems for experimental work. Theory guided research is more efficient because there is a greater chance of success. This man has picked an idea out of thin air and pursued it for no other reason than idle curiosity.

B. This man should not be criticized for his unique albeit different research problem. All too often progress in many fields is thwarted by over-conservatism and rigid adherence to theory. Creativity and independence should be encouraged so that more discoveries can be made and the understanding of nature increased.

Which opinion would you be more willing to accept?

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